Device for a Motor Vehicle That Affords Occupant Protection During the Impact of Energy Directed Against a Motor Vehicle Door As a Result of a Collision

Technical Background

The present invention relates to a device for a motor vehicle that affords occupant protection during the impact of energy directed against a motor vehicle door.

Prior Art

Occupant protection in motor vehicles is a major concern in the construction and development of new motor vehicles. An own development goal is designing a distinct crumble zone in the front and rear part of the vehicle capable of protecting the occupant compartment in collisions from the front and the rear. Occupant protection, however, presents greater problems in collisions from the side due to the short deformation path and the minimal absorption capacity of the lateral structure of the vehicle. Prior art solutions to mitigate occupant risk in lateral collisions provide for reinforcement of the vehicle door. For example, known is molding integrated in the vehicle door which possesses great rigidity in the transverse direction of the vehicle and/or possesses great capacity to absorb energy. For example, DE 196 33 637 A1 describes a vehicle door with lateral impact protection in which the door frames are provided with arch-shaped stay bars which are twisted during collision and deformed under tensile load in such a manner that the effect is similar to that of a guard net.

However, such reinforcement of the side doors by providing corresponding longitudinal beams is not always sufficient enough to protect the occupants in bad collisions as the side door can be pressed through the door opening of the vehicle body upon impact of external forces so that the occupant survival space is drastically reduced and consequently chances of survival.

Furthermore, in the state of the art, a series of measures are known that are suited to transfer forces acting on the side door to the body of the motor vehicle, for example by corresponding large-scale overlapping between the door and the door opening or by bolts extending from the edge of the door. In the case of a collision the bolts enmesh in reinforced recesses in the door opening of the motor vehicle body.
DE AS 22 15 674 describes a means of reinforcing a motor vehicle door essentially comprising an outward-curving beam whose end sections enter corresponding stable recesses when the beam is deformed as the result of an external impact. The beam preferably comprises molded steel sheet formed into the respective shape.

To prevent the preceding measures from increasing the weight of the motor vehicle, DE 41 25 299 C2 describes a means of reinforcing a motor vehicle door, comprising an arch-shaped reinforcement means made of fiber-reinforced composite material for weight reduction. In this case, too, the reinforcement device is located completely inside the door. The reinforcement device comes out of the door with its end sections only in a collision as a result of the deformation of the reinforcement beam. The end sections, in turn, then enter an active connection with the stable support flanks in the door frame of the motor vehicle body.

DE 196 39 519 A1 describes a passenger compartment that provides a transverse beam construction as a means of occupant protection in a lateral collision. In a collision, the transverse beam construction creates a rigid transverse connection between the vehicle door and the center console in such a manner that the seat area in front of the area where the vehicle door enters the passenger compartment should be protected. The transverse beam construction only appears if there is a collision in that pyrotechnical or pneumatic actors extend a hinged cross beam construction, which is otherwise integrated in the seat, door and covering of the console covering, forming a stable transverse connection.

Summary of the Invention

Based on the aforedescribed state of the art, the object of the present invention is to provide an optimized occupant protection system which is able to afford greater occupant protection during lateral impact or a lateral-impact-like collision situation. In

particular, the object is to improve the protection system in such a manner that the deformation energy acting laterally on the vehicle door in a collision is selectively diverted safely away from the area of the vehicle door to prevent drastic reduction of the occupant compartment by collision-caused deformation of the vehicle door, respectively that parts of the door injure the occupants upon penetrating the compartment.

The solution to the object on which the present invention is based is set forth in claim 1. Features that advantageously enhance the inventive idea are the subject matter of the subordinate claims and the description of the invention, in particular with reference to the preferred embodiment.

The device for a motor vehicle that affords occupant protection during the impact of energy directed laterally against a motor vehicle door as a result of a crash, having a connecting structure comprising at least two parts, a first and a second part, of which the first part is firmly connected to the door of the vehicle and the second part is firmly connected to an energy absorbing region of the motor vehicle body located in the interior of the vehicle and the two parts can be brought to enter an active connection via at least one common joining section to selectively divert at least a part of the impact energy acting laterally on the motor vehicle door into the region of the body of the vehicle, is designed in such a manner that the energy input to a transformable material alters the mechanical state of the first and/or the second part and as a result preferably alters their shape due to which the two parts are made to adjoin, interlock and reversibly unlock.

In contrast to the earlier described prior art solutions to increase the rigidity of motor vehicle doors, in which lateral-impact beams projecting through the motor vehicle door are provided which in a collision enter laterally the more stable areas of the body of the motor vehicle in order to in this manner divert in the extreme case the crash energy directed at the motor vehicle door transverse to the action direction, according to the printed publications DE-AS 2 215 674 and DE 196 33 637 A1, the present solution provides a stable connecting structure which is connected to the motor vehicle door, due to which the crash energy, in particular in a lateral impact scenario, is diverted essentially parallel to the action direction into a region of the

motor vehicle body located in the interior of the motor vehicle. The connecting structure can, of course, also absorb, respectively selectively divert forces, directed against the side door acting from other directions on the motor vehicle door than the classical lateral impact direction. The peculiarity of the present device is that, on the one hand, in the ideal case the functionality of the motor vehicle door remains unimpaired, i.e. the door can still be opened and closed freely just as before. On the other hand, however a connecting structure, which, when the door is closed, is flush between the motor vehicle door and the interior of the motor vehicle body, preferably, in the region of the substructure of the seat, has a stable support function for the impact energy acting, preferably, in longitudinal direction to the connecting structure in a crash case. Moreover, repeatable locking and unlocking permits coupling with progressive so-called pre-crash sensors, for example in the form of optical or radar-based sensors, which are able to convey technically caused erroneous information on the critical extent of the detected situation and require greater analysis and evaluation input to confirm the report of an imminent crash and which on the other hand lower the reaction time, e.g. for locking. The described reversible locking renders possible erroneous information more tolerable and permits as a consequence greater overall safety. There are several embodiments for realizing a connecting structure according to these requirements.

In the simplest case, it is obvious to make the first and second part completely or partially out of a transformable material and to activate the same in a collision. Fundamentally, a multiplicity of different, state-of-the-art transformable materials, preferably solid-state transformable materials such as piezo-ceramics, electrostrictive ceramics, shape-memory alloys (SMA) can be employed. Such type transformable materials permit direct use provided that the parts connected to the motor vehicle door and to the interior of the motor vehicle body are shaped in a manner that is suited for the connecting structure.

Furthermore, state-of-the-art are fluid transformable materials, such as for example piezo-polymers, electrorheological fluids, polymer gels and magnetorheological fluids, which, provided they are inside a suitably selected encapsulation, are, under circumstances, also suited for use within the scope of the connecting structure.

Using transformable materials in the proposed connecting structure, permits selectively adjusting the rigidity and dampening behavior of the parts entering into an active connection in a collision and thus in the crash-relevant and occupant-relevant body-seat system. For example, transformable materials made of shape-memory materials are able to change shape by means of selective electric current input in a predetermined manner and to simultaneously influence the material rigidity and/or material dampening properties. This property is advantageously utilized in the invented device in that a connecting structure made of a shape-memory material, which provides at least one joining section having at least two separatable parts respectively partial areas, is activatable by selective electrical energy input in a crash situation in such a manner that both parts enter a close and stable active connection via which the crash energy acting on the motor vehicle door along the connecting structure is selectively diverted into a stable area, preferably into the floor region of the motor vehicle or an energy-absorbing area.

In addition to the selective diversion of force along the connecting structure, the used transformable material permits altering the rigidity behavior, respectively the dampening behavior, by means of actively controlling a form of energy acting selectively on the transformable material, for example in the form of electrical, thermal or similar energy, with the aim of reduced physiological stress on the occupants inside the motor vehicle. Regulation of, respectively control of the rigidity behavior, respectively the dampening behavior of the used transformable material can be carried out according to various target functions, for example with the aim of reduced neck acceleration of the occupants inside the motor vehicle. The target function depends basically on the age, weight, sex, size as well as the respective sitting position of the occupants inside the motor vehicle.

The device can, of course, not only be successfully used in the side doors of a motor vehicle, but rather the connecting structure is also suited for stabilizing a hatchback. In the case of side doors, it has proven to be especially advantageous if that part of the connecting structure that is connected to the stable interior of the motor vehicle body is firmly in active connection with the motor vehicle body in the region under the motor vehicle seat. Such type fixation of the connecting structure provided in the interior of the motor vehicle is particularly physiologically gentle for the occupant on

the motor vehicle seat in crash situations, especially if the connecting structure is made of the aforedescribed transformable materials with the adjustable dampening and rigidity behavior.

The aforedescribed design of the connecting structure using transformable materials, however, does not necessarily presuppose activation of the respective material by means of externally applied energy, such as for example electrical energy input, it is just as possible to use the connecting structure designed in the aforedescribed manner solely passively in an advantageous manner. Thus, a connecting structure made of shape-memory material permits creation, respectively material adjustment of the course of rigidity and/or course of dampening utilizing corresponding material inherent properties (e.g. super elasticity or material hysteresis), which permits predetermined adjustment of the impact energy acting on the motor vehicle body during lateral impact and, therefore, acting on the occupant seated on the motor vehicle seat.

Just as feasible is selective quasistatic adjustment of the material properties, respectively of the component properties analogue to the above description. For example, if using shape-memory metals, it is feasible to use thermal activation for variable adjustment of the material hysteresis.

Furthermore, it is feasible to utilize the crash energy itself for producing a joining connection. The crash energy can be utilized to lock the parts of the connecting structure. An active element can subsequently effect separation of the parts to permit, respectively to facilitate, opening the door and rescuing the occupants.

It is just as feasible to utilize the crash energy for activating the transformable material. In the case of a shape-memory metal, the mechanical energy can be converted into thermal energy by means of which the actual activation of the shape-memory effect is then achieved.

Moreover, preferred embodiments are feasible which provide complicatedly designed connecting structures. Thus it is feasible to design each first part and each second

part of the connecting structure double in such a manner that a parallel arrangement of the first parts and the second parts entering an active connection is possible. Thus, the first part can be executed as a pipe with a separate rod running inside it. The two components can be made of different materials. Alternatively or in combination with the preceding variant, the second part can be divided in two in the longitudinal direction, with one section being made of the transformable material and the other of a conventional material. The preceding considerations are intended to show that there are practically no limits to the variety of different manners of a design of the connecting structure to optimize the connecting structure with the aim of effectively diverting, respectively absorbing, the crash energy from the area of the motor vehicle door.

The device that affords occupant protection during the impact of energy directed against a motor vehicle door as the result of a collision is made more apparent in the following description of a single preferred embodiment with reference to the accompanying figure.

Description of the Invention

The figure shows a partial cross section of a motor vehicle, in whose interior 1 a person 2 is seated on a motor vehicle seat 3. The motor vehicle seat 3 is connected via corresponding locking elements 4 to the floor region of the body 5 of the motor vehicle. The manner in which the locking elements function is irrelevant here. A motor vehicle door 6, which is shown in a closed state in the cross section representation, is located to the left of the person 2. Of special significance is that the connecting structure 7, which is firmly hinged with its end 71 inside the motor vehicle door 6 and firmly connected with its end 72 to the floor region of the motor vehicle body 5. It is apparent that in the event of lateral impact on the motor vehicle door 6, the impact energy E is very effectively diverted via the connecting structure 7 into the floor region of the motor vehicle door 6 without any major deformation of the motor vehicle door 6 due to the fact that the connecting structure 7 has a longitudinal extension oriented in the active direction of the crash energy E. The energy E is conveyed along this longitudinal extension into the stable floor region of the body 5.

In order not to impair the motor vehicle door's manner of functioning, the connecting structure 7 is provided with at least one joining section F separating the connecting structure 7 into parts T1 and T2.

In order to ensure that, in a collision, the parts T1 and T2 of the connecting structure 7 enter a close, stable connection to divert the impact energy E into the floor region of the motor vehicle body 5 and to protect the person 2 against physiological injury, the joining sections are constructed in a corresponding manner and enter a stable active connection. For possible preferred embodiments to realize such a type active connection of the two parts T1 and T2 reference is made to the preceding description.

The object to improve occupant protection in a lateral crash as well as in combination crash situations on which the device is based is achieved by selective reduction of the physiological stress on the occupants in a crash by means of controlled influencing of the forces, respectively accelerations respectively deformations, acting on the seat. This controlled influencing can be achieved in an especially advantageous manner by designing a connecting structure between the motor vehicle door and the rigid areas of the substructure of the seat by selective use of a transformable material, for example a shape-memory material.

List of References

1 interior of the motor vehicle

2 person

3 motor vehicle seat

4 locking element

5 body of the motor vehicle

6 motor vehicle door

7 connecting structure

71,72 ends of the connecting structure